SPECIFICATION AMENDMENTS

On page 1, insert above line 1, insert--Priority Claim

The present application claims priority on European Patent Application 03250229.6 filed 14 January 2003.--

On page 1, above line 1, insert--Field of the Invention--

Paragraph on page 1, line 1 has been amended as follows:

-- The present invention relates to a process for the generation of electricity and the production of a concentrated carbon dioxide (CO_2) stream using a molten carbonate fuel cell (MCFC).--

On page 1, above line 5, insert--Background of the Invention--

Paragraph on page 1, line 25, ending on page 2, line 6, has been amended as filed:

-- In a conventional operation of a MCFC, the anode off-gas is recycled, typically after combustion of the ~~non-utilised~~ non-utilized hydrogen and carbon monoxide, to the cathode chamber to provide for the carbon dioxide needed at the cathode layer. Air is fed to the cathode chamber to provide for the oxygen needed. The exhaust gas of the system, i.e. the cathode off-gas, comprises diluted carbon dioxide, usually in a concentration of about 3-5 % (v/v).--

Paragraph on page 2, line 7 has been amended as follows:

-- In order to minimize ~~minimise~~ the amount of carbon dioxide emitted to the atmosphere, it is advantageous to operate a MCFC in such a way that the carbon dioxide produced is obtained in a concentrated form. Carbon dioxide in a highly concentrated form, typically above 80 % (v/v), can be efficiently liquefied and subsequently used in enhanced oil recovery or the recovery of coal bed methane. Also for effective sequestration of carbon dioxide, a concentrated carbon dioxide stream is needed. Carbon dioxide concentrated to about 50 % (v/v), can usefully be applied in the food and paper industry.--

On page 2, delete line 31 and 32.

On page 3, delete line 1 and 2.

On page 3, after line 2, insert-- Summary of the Invention--

Paragraph on page 3, line 3 has been amended as follows:

-- Accordingly, the present invention is directed ~~relates~~ to a process ~~as defined in claim 1.~~ for the generation of electricity and the production of a concentrated carbon dioxide stream using a molten carbonate fuel cell, the fuel cell comprising an electrolyte sandwiched between an anode and a cathode, an anode chamber and a cathode chamber, wherein the process comprises:

feeding a fuel gas to the anode chamber and a cathode inlet gas comprising carbon dioxide and molecular oxygen to the cathode chamber;

producing electricity, an anode off-gas and a cathode off-gas via anode and cathode reactions;

feeding at least part of the anode off-gas to a catalytic afterburner wherein it is oxidized with an oxidant to obtain an oxidized anode off-gas;

recycling the remainder of the anode off-gas to the anode chamber; wherein

the oxidant consists of part of the cathode off-gas and/or part of a molecular oxygen containing external oxidant stream, which external oxidant stream comprises at most 20% (v/v) nitrogen;

the oxidized anode off-gas is brought into heat-exchange contact with the remainder of the cathode off-gas and the remainder of the external oxidant stream to obtain cooled anode off-gas and a heated mixture of cathode off-gas and external oxidant;

the cathode off-gas is cooled before it is brought in heat-exchange contact with the oxidized anode off-gas;

the cooled anode off-gas and the heated mixture of cathode off-gas and external oxidant are fed to the cathode chamber as the cathode inlet gas;

as soon as a set point in the carbon dioxide concentration at the cathode chamber outlet is reached, part of the cooled anode off-gas is withdrawn from the process.--

On page 3, after line 4, insert--Brief Description of the Drawings

The invention will be illustrated by means of schematic Figures 1 to 4.

Figure 1 shows a conventional process for operating a molten carbonate fuel cell.

Figure 2 shows a process according to the invention wherein a mixture of cathode off-gas and external oxidant is used as oxidant for the catalytic afterburner.

Figure 3 shows a process according to the invention wherein only cathode off-gas is used as oxidant for the catalytic afterburner.

Figure 4 shows a process according to the invention wherein only external oxidant is used as oxidant for the catalytic afterburner.--

On page 3, above line 5, insert--Detailed Description of the Invention--

Paragraph on page 3, line 5 has been amended as follows:

-- In the process according to the invention, cathode off-gas which is diluted with a molecular oxygen containing external oxidant stream which comprises at most 20% (v/v) of nitrogen, and oxidized ~~oxidised~~ anode off-gas are fed to the cathode chamber. The anode off-gas is catalytically oxidized ~~oxidised~~ with relatively pure oxygen, i.e. cathode off-gas and/or the external oxidant stream. Thus, the amount of nitrogen or other inert gases in the system is minimized ~~minimised~~, resulting in an oxidized ~~oxidised~~ anode off-gas stream which contains mainly carbon dioxide and water. From this stream, highly concentrated carbon dioxide may ~~can~~ easily be withdrawn after separation of the water from it, e.g. by condensation.--

Paragraph on page 4, line 3, has been amended as follows:

-- The fuel gas fed to the anode chamber is preferably a gaseous hydrocarbon gas such as natural gas, methane, biogas, or land-fill gas that is reformed in the anode chamber. Reference to reforming is to the reaction of the fuel with steam to form carbon monoxide and hydrogen, such as given by equation (1) for methane. An advantage of reforming in the anode chamber or internal reforming is that the heat produced by the charge transfer in the electrolyte layer may ~~can~~ then be directly used for the endothermic reforming reaction. Reforming in the anode chamber is typically achieved by placing an additional Ni-containing reforming catalyst in the anode chamber.--

Paragraph on page 5, line 13 has been amended as follows:

-- In the catalytic afterburner, the unconverted carbon monoxide and hydrogen in the anode off-gas are oxidized ~~oxidised~~. The amount of oxidant fed to the catalytic afterburner is preferably the stoichiometric amount needed for oxidizing ~~oxidising~~ the hydrogen and carbon monoxide. Thus, an oxidized ~~oxidised~~ anode off-gas containing carbon dioxide, steam and substantially no oxygen is obtained. The oxidant used in the catalytic afterburner might be part of the cathode off-gas, part of the external oxidant stream comprising at most 20% v/v of nitrogen or a combination of both.--

Paragraph on page 5, line 23 has been amended as follows:

-- The oxidized ~~oxidised~~ anode off-gas is brought into heat exchange contact with the remainder of the cathode off-gas and the remainder of the external oxidant stream to obtain cooled anode off-gas and a heated mixture of cathode off-gas and external oxidant, which are both fed to the cathode chamber as the cathode inlet gas.--

Paragraph on page 5, line 31, ending on page 6, line 13, has been amended as follows:

-- In the process according to the invention, the cathode inlet gas will provide for cooling of the fuel cell, i.e. of the stack of fuel cell elements each containing an electrolyte layer sandwiched between an anode layer and a cathode layer. Therefore, the temperature of the cathode inlet gas will be lower than the temperature of the cathode off-gas. In order to maintain the cathode inlet gas at the appropriate cathode inlet temperature, the cathode off-gas is cooled before being brought in heat-exchange contact with the hot oxidized ~~oxidised~~ anode off-gas. In order to achieve cooling of the stack by the cathode inlet gas, it is preferred that the cathode inlet gas flow is higher than the flow that contains the stoichiometric amount of oxygen needed to maintain the electrochemical reaction. Preferably, the cathode flow is 3-6 times the stoichiometric flow. --

Paragraph on page 7, line 8 has been amended as follows:

-- A concentrated carbon dioxide stream may ~~can~~ be obtained by further cooling the withdrawn anode off-gas to a temperature at which the steam condenses. Water may ~~can~~ thus be easily separated from the withdrawn anode off-gas.--

On page 7, delete line 16-28.

Paragraph on page 7, line 29, ending on page 8, line 9, has been amended as follows:

-- In Figure 1 is shown part of a molten carbonate fuel cell 1 comprising an element 2 of an electrolyte layer sandwiched between an anode layer and a cathode layer. Fuel gas is fed to anode chamber 5 via line 6. The anode off-gas is discharged from anode chamber 5 via line 7. The main part of the anode off-gas is led via line 8 to catalytic afterburner 9. Air is fed to catalytic after burner 9 via line 10. The remaining carbon monoxide and hydrogen in the anode off-gas is oxidized ~~oxidised~~ in catalytic afterburner 9. The oxidized ~~oxidised~~ anode off-gas and air are fed via lines 11 and 12, respectively, to cathode chamber 13. Part of the anode off-gas is recycled to anode chamber 5 via line 14. Cathode off-gas is discharged from cathode chamber 13 via line 15.--

Paragraph on page 8, line 10, has been amended as follows:

-- In Figure 2 is shown part of a molten carbonate fuel cell 1 operated according to a process of the invention. The cathode off-gas is led via line 16 to heat exchanger 17, wherein it is cooled to ambient temperature. Water is thus condensed from the cathode off-gas and withdrawn via line 18. Substantially pure oxygen from a PSA unit (not shown) is fed via line 19 to the cooled cathode off-gas in line 20, thus obtaining a mixture of cathode off-gas and oxygen. The amount of the mixture to provide for the amount of oxygen needed for combustion of the unconverted carbon monoxide and hydrogen in the anode off-gas is fed via valve 21 and line 22 to catalytic afterburner 9. The remainder of the mixture is led via line 23 to heat exchanger 24. Oxidized ~~Oxidised~~ anode off-gas is led via line 25 to heat exchanger 24. In heat exchanger 24, the hot oxidized ~~oxidised~~ anode off-gas heats the cold mixture of cathode off-gas and oxygen to the appropriate cathode inlet temperature. Cooled anode off-gas and heated mixture of cathode off-gas and oxygen are fed into cathode chamber 13 via lines 26 and 27, respectively. Part of the cooled anode off-gas is withdrawn from the process via line 28.--

Paragraph on page 9, line 19, ending on page 10, line 18, has been amended as follows:

-- In an on-stream process in a fuel cell system as shown in Figure 2, 1.0 NL/s of fresh methane is supplied via line 6 to anode chamber 5 and a stream of 19.7 NL/s containing 64 % (v/v) O_2, 29 % (v/v) CO_2 and 7 % (v/v)O_2 and having a temperature of

600 °C is supplied to cathode chamber 13 via lines 26 and 27. 25.6 NL/s anode off-gas having a temperature of 675 °C and containing 63 % (v/v) CO_2, 27 % (v/v) H_2O, 4 % (v/v) H_2 and 5 % (v/v) CO is discharged from anode chamber 5 via line 7. 19.2 NL/s of the anode off-gas is recycled to anode chamber 5 via line 14, 6.4 NL/s of the anode off-gas is fed to catalytic afterburner 9 via line 8. The anode inlet temperature is 600 °C. A stream of 14.6 NL/s of cathode off-gas having a temperature of 675 °C and containing 75 % (v/v) O_2, 15 % (v/v) CO_2 and 10 % (v/v) H_2O is discharged from cathode chamber 13 via line 16 and cooled to room temperature in heat exchange 17. 1.5 NL/s of water is separated from the cathode off-gas via line 18. To the remaining 13.1 NL/s of cooled cathode off-gas, 2.0 NL/s of substantially pure oxygen is added via line 19. Of the resulting mixture that comprises 85 % (v/v) O_2 and 15 % (v/v) CO_2, 0.4 NL/s is supplied via line 22 to catalytic afterburner 9 as oxidant and 14.6 NL/s is led to heat exchanger 24 via line 23. In afterburner 9, the anode off-gas is oxidized ~~oxidised~~ to an oxidized ~~oxidised~~ anode off-gas containing 69 % (v/v) CO_2 and 31 % (v/v) H_2O. 1.5 NL/s of the oxidized ~~oxidised~~ anode off-gas is withdrawn from the system via line 28. The remainder of the oxidized ~~oxidised~~ anode off-gas and the heated oxidant make up the cathode inlet stream of 19.7 NL/s. Reference herein to NL/s is to liter ~~litres~~ at standard temperature and pressure conditions (STP; 0 °C and 1 atm.) per second.--

On page 11, above line 1, insert --We claim:--